



US009406389B2

(12) **United States Patent**  
**Chandrasekhar**

(10) **Patent No.:** **US 9,406,389 B2**  
(45) **Date of Patent:** **\*Aug. 2, 2016**

(54) **ELECTRONICALLY COUPLING A DATA LINE TO A SOURCE FOR BIASING REGARDLESS OF STATES OF MEMORY CELLS COUPLED TO THE DATA LINE**

(71) Applicant: **MICRON TECHNOLOGY, INC.**,  
Boise, ID (US)

(72) Inventor: **Uday Chandrasekhar**, San Jose, CA  
(US)

(73) Assignee: **Micron Technology, Inc.**, Boise, ID  
(US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/535,567**

(22) Filed: **Nov. 7, 2014**

(65) **Prior Publication Data**

US 2015/0063035 A1 Mar. 5, 2015

**Related U.S. Application Data**

(63) Continuation of application No. 13/417,475, filed on Mar. 12, 2012, now Pat. No. 8,897,071, which is a continuation of application No. 12/265,989, filed on Nov. 6, 2008, now Pat. No. 8,134,868.

(51) **Int. Cl.**  
**G11C 16/04** (2006.01)  
**G11C 16/06** (2006.01)  
**G11C 16/26** (2006.01)  
**G11C 11/56** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G11C 16/26** (2013.01); **G11C 11/5642** (2013.01); **G11C 16/0483** (2013.01)

(58) **Field of Classification Search**  
CPC . G11C 16/26; G11C 16/0483; G11C 11/5642  
USPC ..... 365/185.01, 185.05, 185.17, 185.18, 365/185.21, 185.33  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

6,845,042 B2	1/2005	Ichige et al.	
8,134,868 B2 *	3/2012	Chandrasekhar ..	G11C 11/5642 365/185.03
8,897,071 B2 *	11/2014	Chandrasekhar ..	G11C 11/5642 365/185.01
2006/0256620 A1	11/2006	Nguyen et al.	
2006/0274566 A1	12/2006	Takashima et al.	
2007/0159886 A1	7/2007	Kang	
2007/0247908 A1 *	10/2007	Aritome et al. ....	365/185.17
2007/0263462 A1	11/2007	Roohparvar	
2008/0094902 A1 *	4/2008	Lee .....	G11C 16/3427 365/185.17

\* cited by examiner

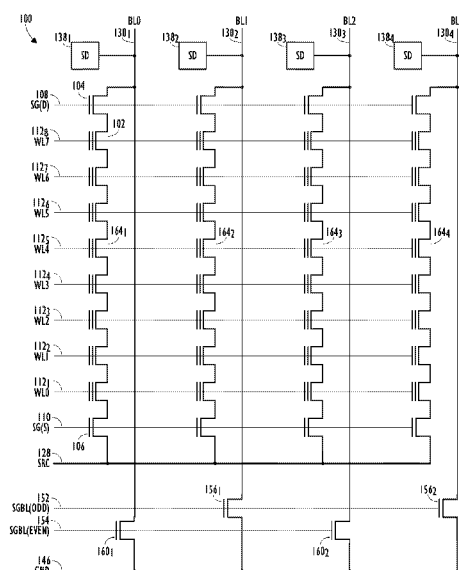
*Primary Examiner* — Tha-O H Bui

(74) *Attorney, Agent, or Firm* — Dicke, Billig & Czaja, PLLC

(57) **ABSTRACT**

Memory devices and methods are disclosed, such as those facilitating data line shielding by way of capacitive coupling with data lines coupled to a memory string source line. For example, alternating data lines are sensed while adjacent data lines are coupled to a common source line of the data lines being sensed. Data line shielding methods and apparatus disclosed can reduce effects of source line bounce occurring during a sense operation of a memory device.

**14 Claims, 9 Drawing Sheets**



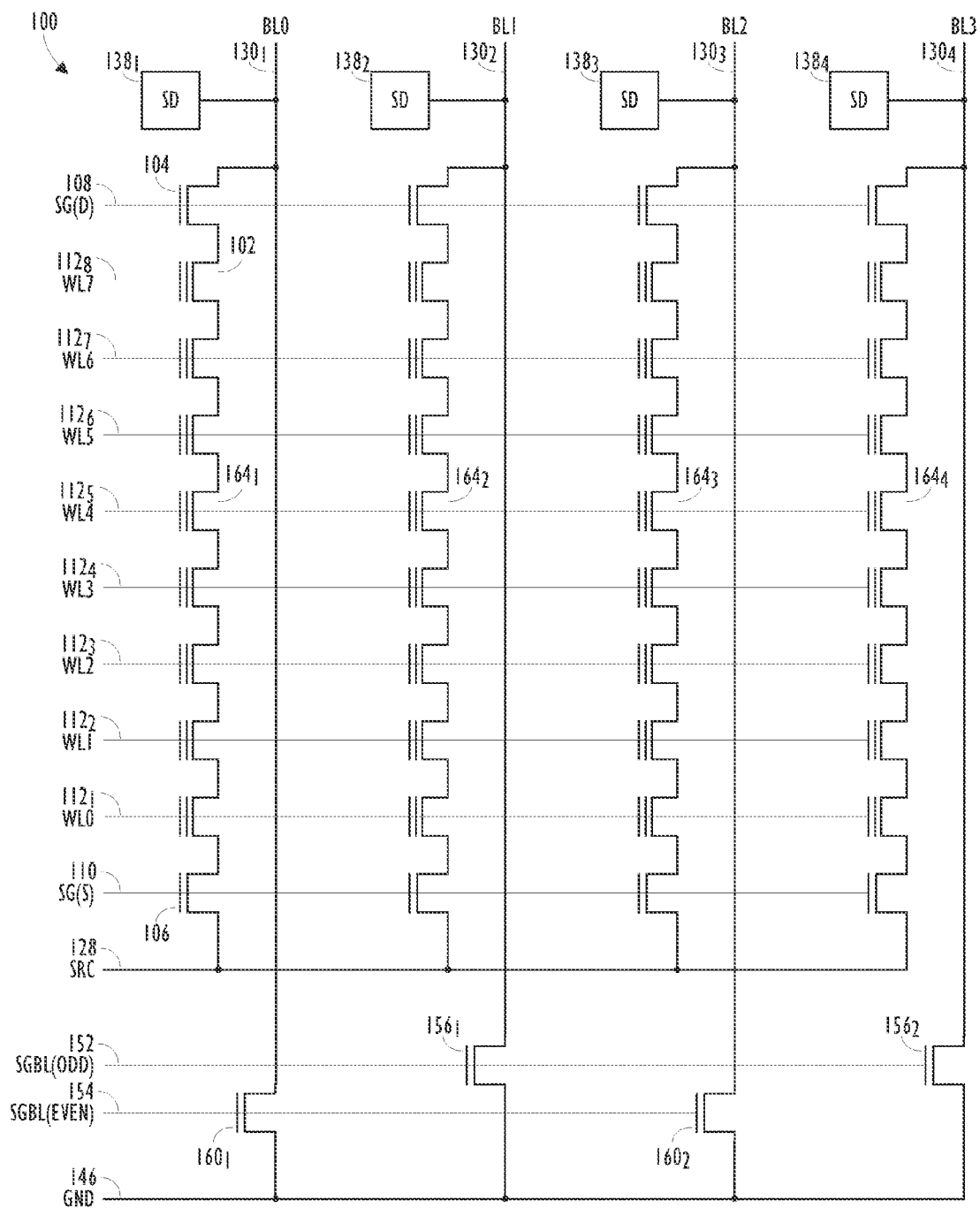


FIG. 1

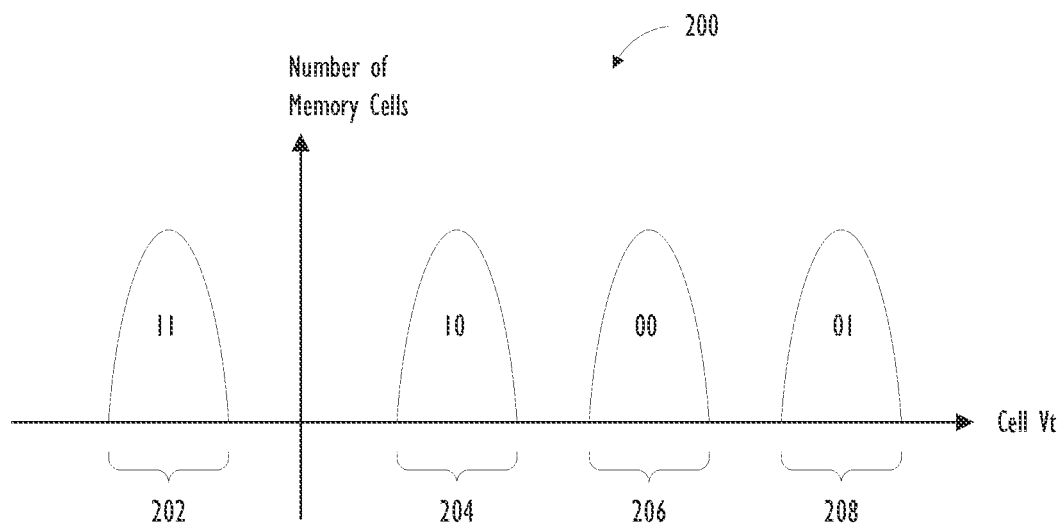


FIG. 2

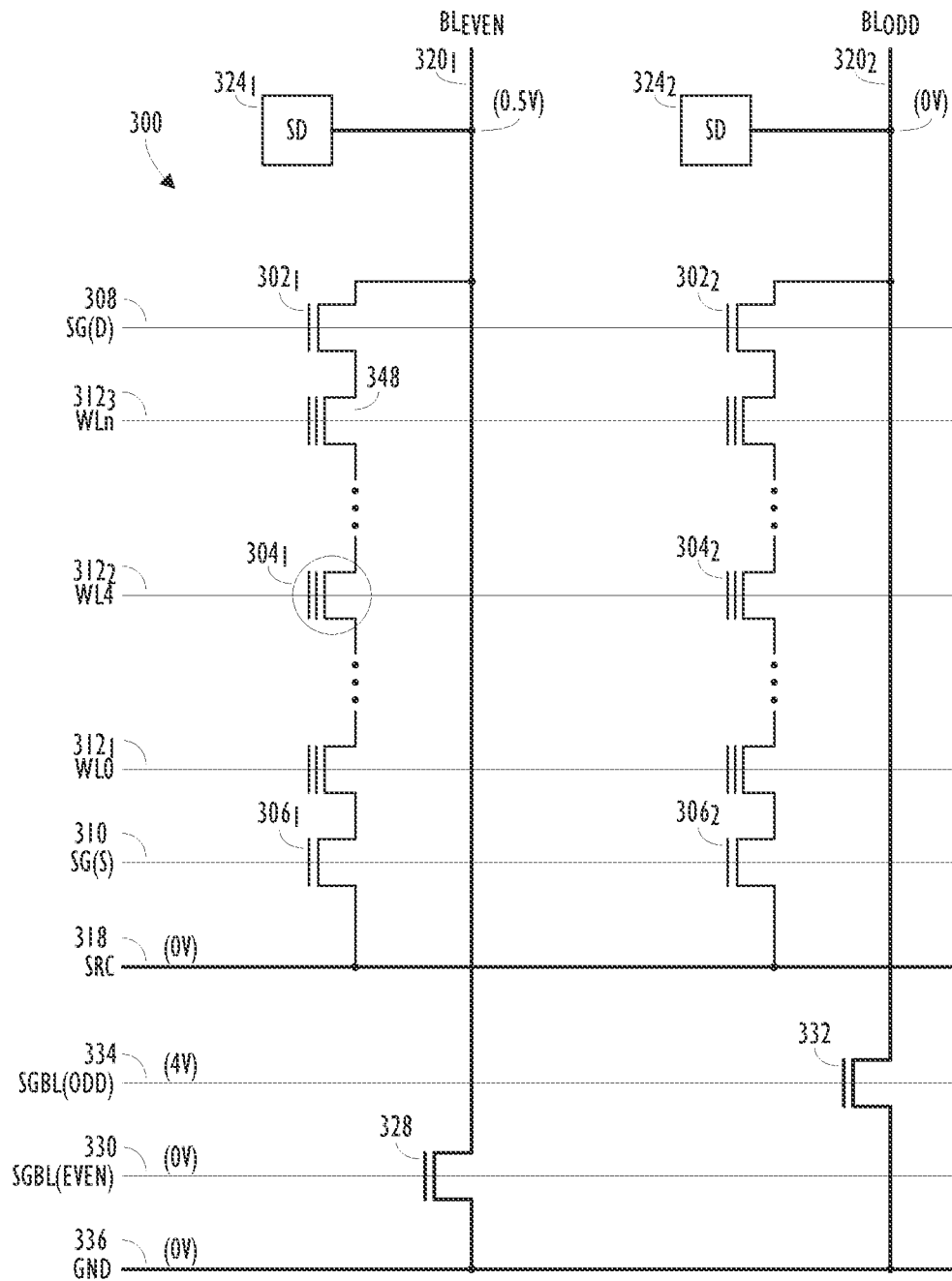


FIG. 3

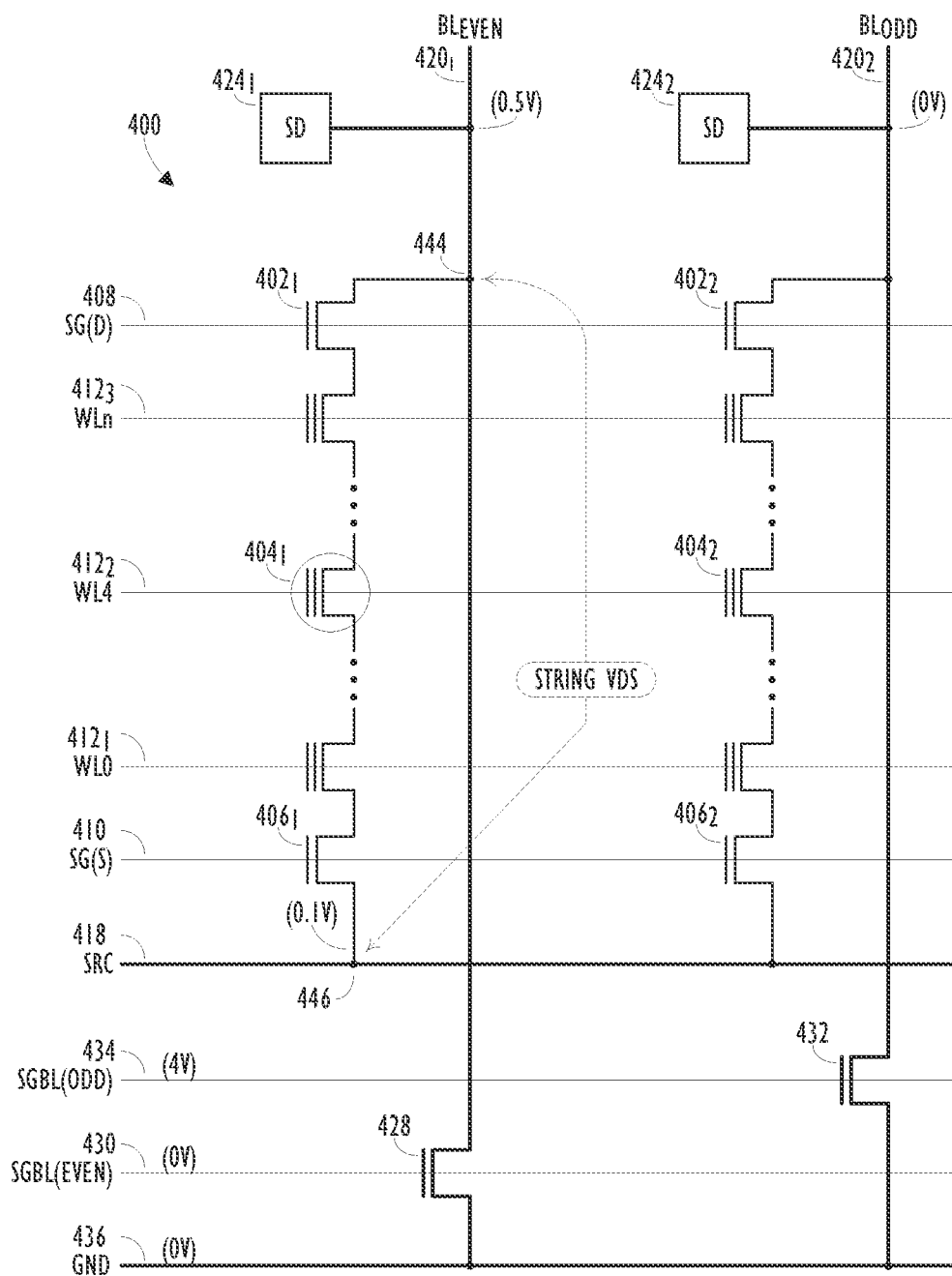


FIG. 4

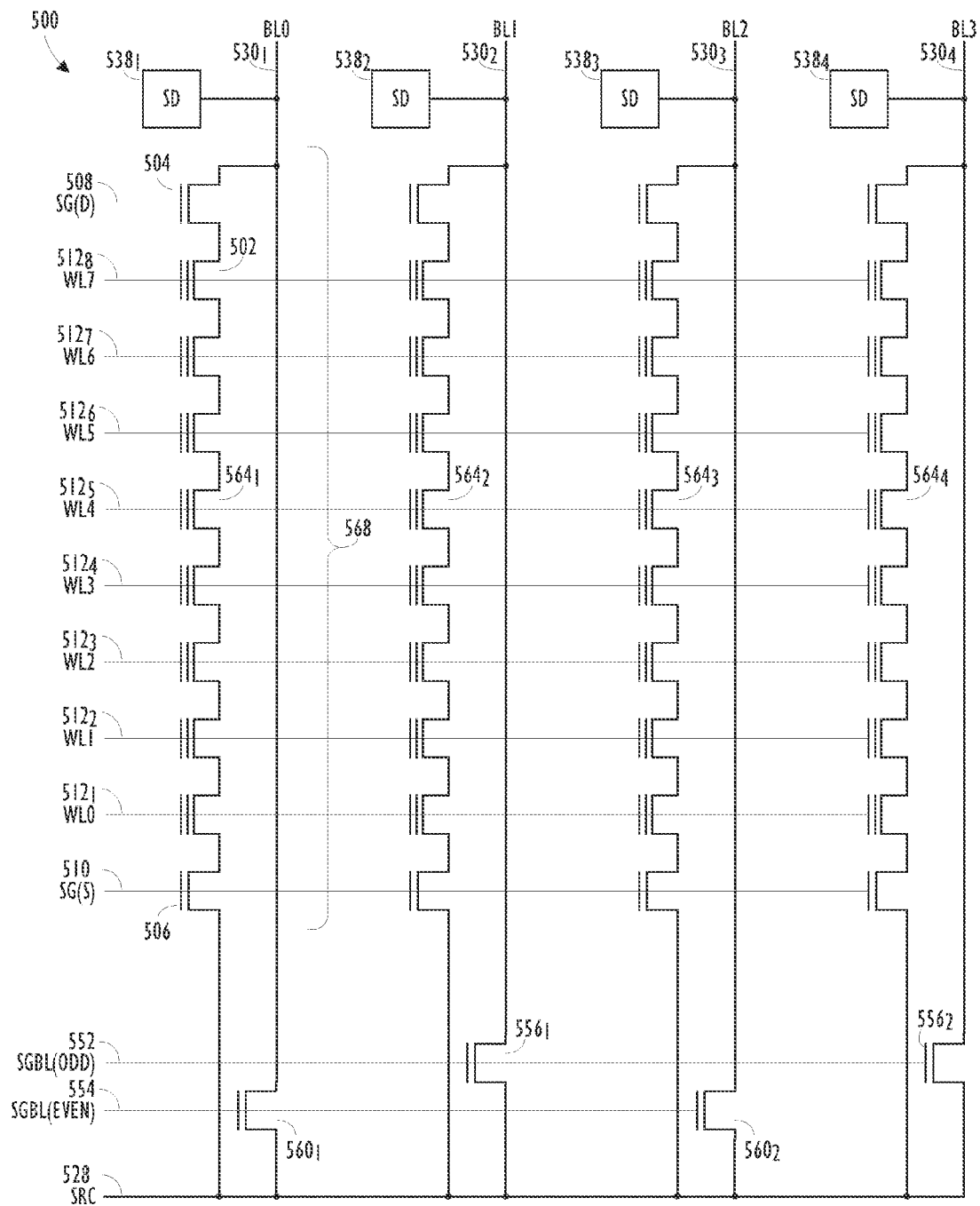


FIG. 5

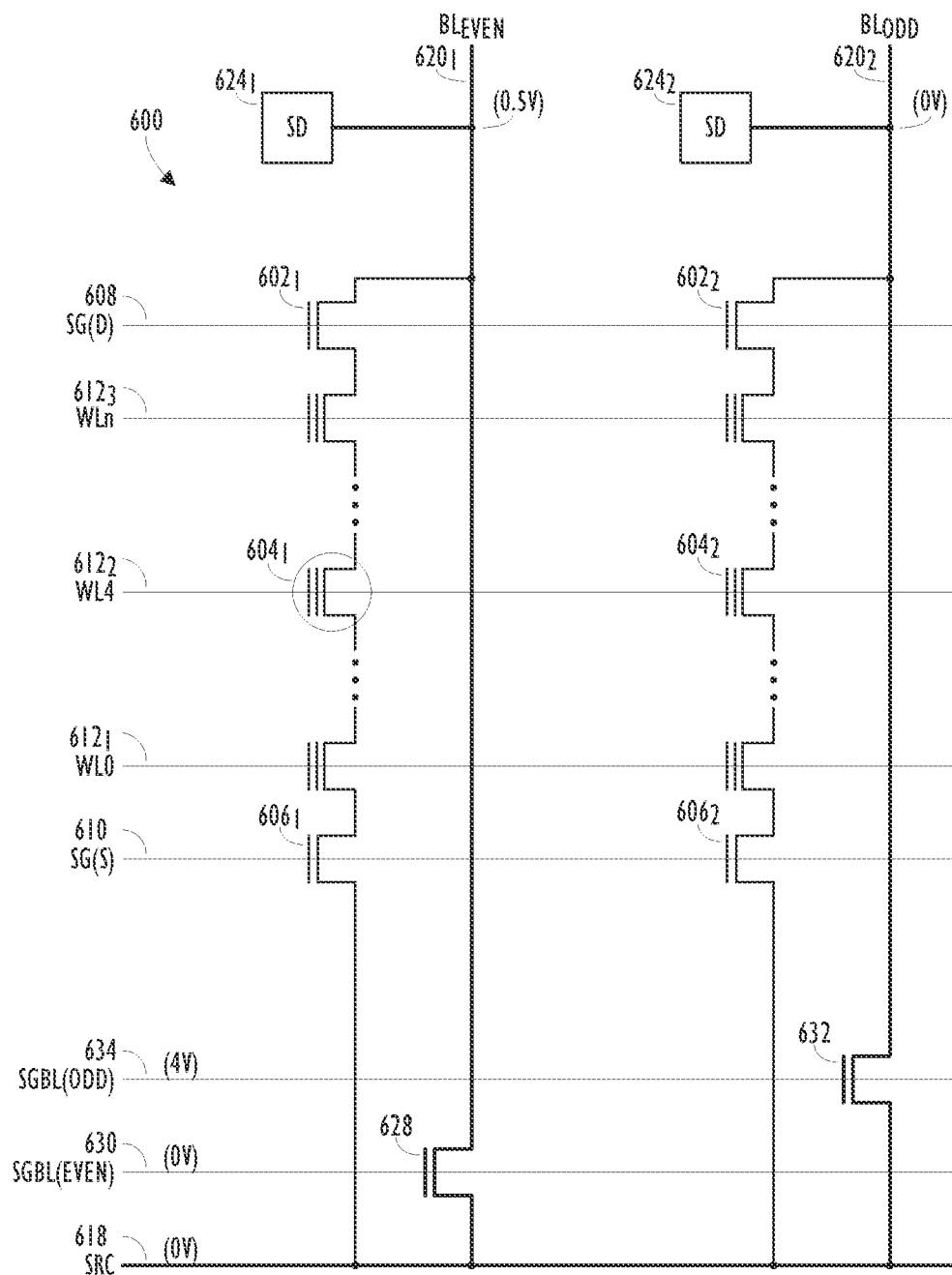


FIG. 6

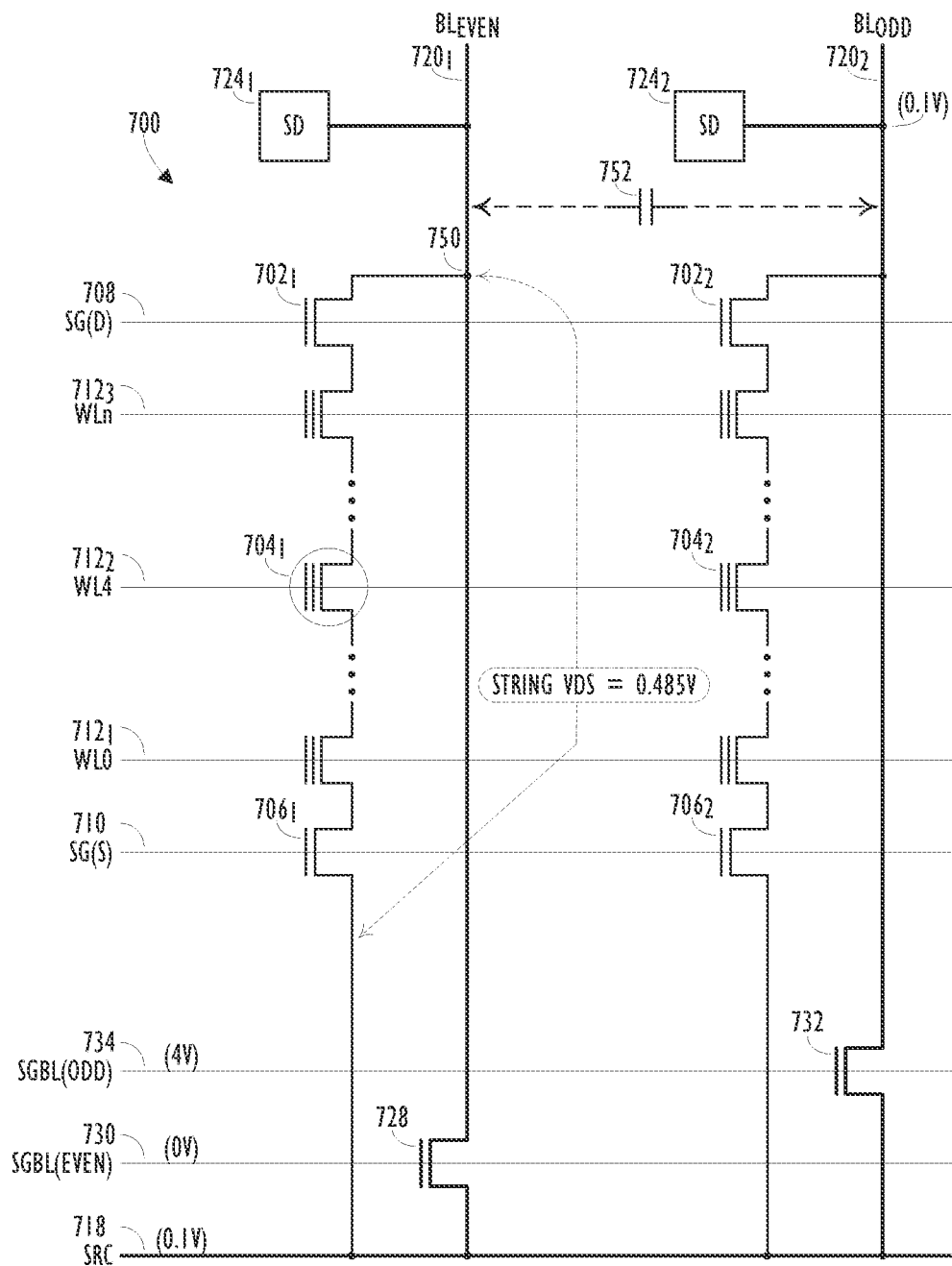


FIG. 7



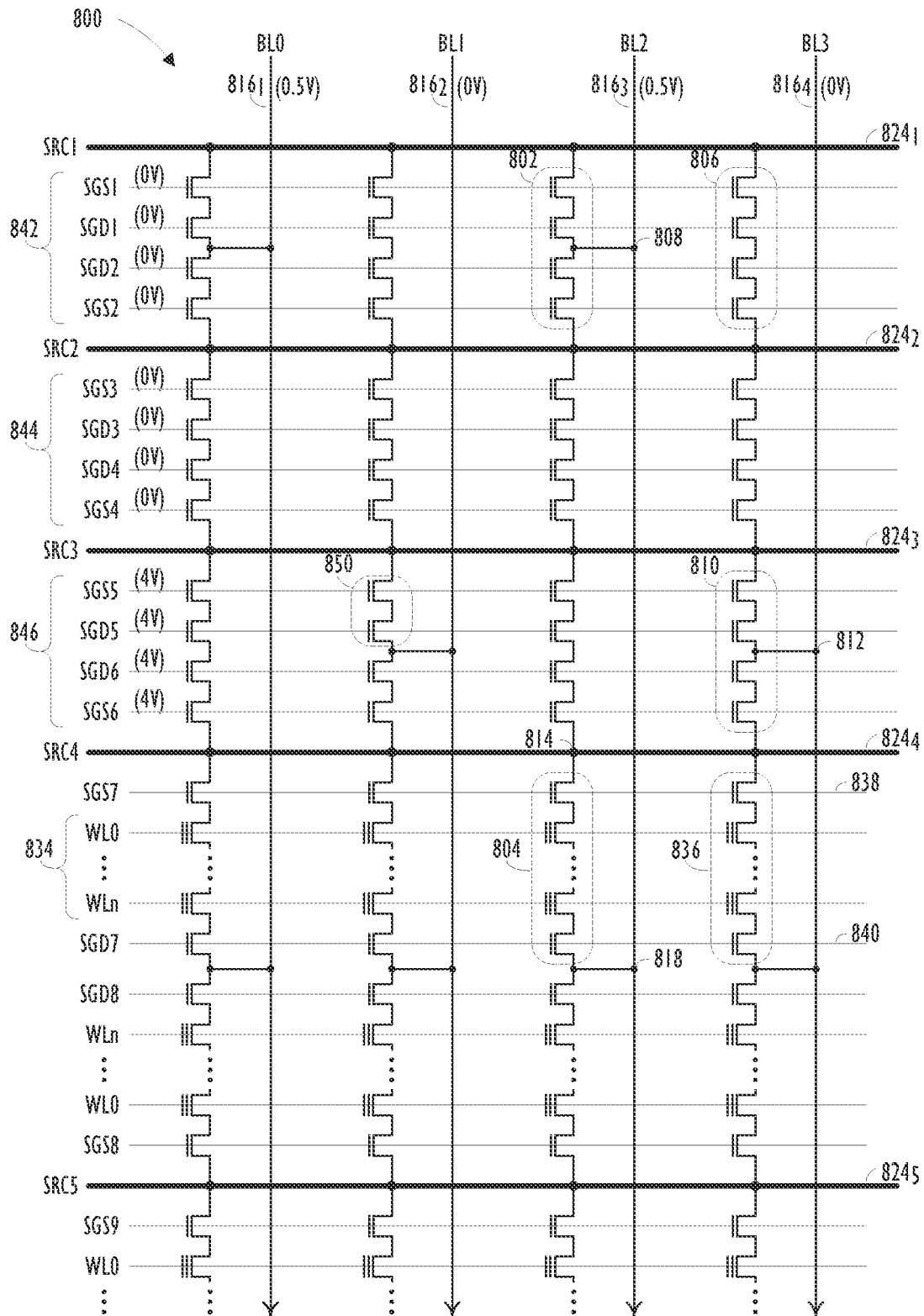


FIG. 8

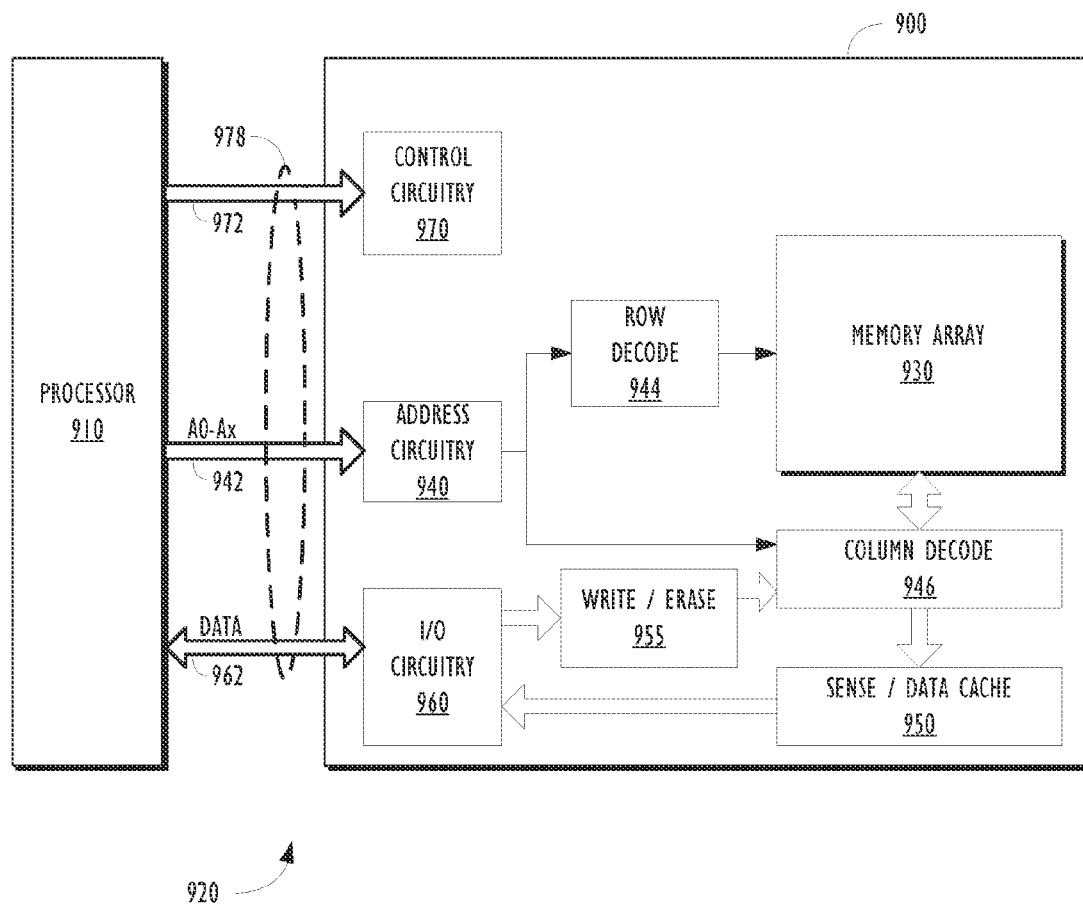


FIG. 9

1

# ELECTRONICALLY COUPLING A DATA LINE TO A SOURCE FOR BIASING REGARDLESS OF STATES OF MEMORY CELLS COUPLED TO THE DATA LINE

## RELATED APPLICATIONS

This is a continuation of U.S. application Ser. No. 13/417,475, titled "MEMORY DEVICE BIASING METHOD AND APPARATUS," filed Mar. 12, 2012, and issued as U.S. Pat. No. 8,897,071 on Nov. 25, 2014, which is a continuation of U.S. application Ser. No. 12/265,989, titled "MEMORY DEVICE BIASING METHOD AND APPARATUS," filed Nov. 6, 2008 and issued as U.S. Pat. No. 8,134,868 on Mar. 13, 2012, both of which are commonly assigned and are incorporated herein by reference in their entirety.

## TECHNICAL FIELD

The present disclosure relates generally to semiconductor memory devices and more particularly, in one or more embodiments, to biasing methods in non-volatile memory devices.

## BACKGROUND

Flash memory devices have developed into a popular source of non-volatile memory for a wide range of electronic applications. Flash memory devices typically use a one-transistor memory cell (e.g., floating gate) that allows for high memory densities, high reliability, and low power consumption. Changes in threshold voltage of the cells, through programming of charge storage nodes (e.g., floating gates or trapping layers) or other physical phenomena (e.g., phase change or polarization), determine the data value of each cell. Common uses for flash memory and other non-volatile memory include personal computers, personal digital assistants (PDAs), digital cameras, digital media players, digital recorders, games, appliances, vehicles, wireless devices, mobile telephones, and removable memory modules, and the uses for non-volatile memory continue to expand.

Flash memory typically utilizes one of two basic architectures known as NOR Flash and NAND Flash. The designation is derived from the logic used to read the devices. FIG. 1 illustrates a NAND type flash memory array architecture 100 wherein the floating gate memory cells 102 of the memory array are arranged in a logical matrix of rows and columns. The memory cells 102 of the array are also arranged together in strings (e.g., NAND strings), typically of 8, 16, 32, or more each, where the memory cells in a string are connected together in series, source to drain, between a source line 128 and a data line 130, often referred to as a bit line. The array is then accessed by a row decoder activating a logical row of floating gate memory cells by selecting a particular access line, often referred to as a word line WL7-WL0 112<sub>8</sub>-112<sub>1</sub>, connected to their control gates. As is known to those skilled in the art, the number of word lines and bit lines might be much greater than those shown in FIG. 1.

In addition, bit lines BL0-BL3 130<sub>1</sub>-130<sub>4</sub> can also be driven high or low depending on the operation being performed. For example, during a typical read operation, even numbered bit lines BL0 130<sub>1</sub> and BL2 130<sub>3</sub>, are pre-charged by sense devices 138<sub>1</sub> and 138<sub>3</sub>, respectively, to a particular bias level. Odd numbered bit lines BL1 130<sub>2</sub> and BL3 130<sub>4</sub> are driven low to a common ground connection GND 146, such as through gates 156<sub>1</sub> and 156<sub>2</sub>. In a subsequent read operation, even numbered bit lines may be driven to GND 146

2

while odd numbered bit lines are read. The bit line select gates 156<sub>1</sub>-156<sub>2</sub>, 160<sub>1</sub>-160<sub>2</sub> thereby allow for either the even or odd bit lines to be coupled to a common ground potential node, GND 146. Select gates 156/160, are typically large, high voltage devices which are located outside of the array. By coupling every other bit line (e.g., alternate bit lines) to GND 146 during a read operation, the grounded bit lines serve as a shield (e.g., through capacitive coupling) between to the two adjacent strings (e.g., precharged bit lines) of memory cells being read, such as 164<sub>1</sub> and 164<sub>3</sub>, for example.

Bit lines BL0-BL3 130<sub>1</sub>-130<sub>4</sub> are coupled to sensing devices (e.g., sense amplifiers) 138<sub>1</sub>-138<sub>4</sub> that detect the state of each cell by sensing voltage on a particular bit line 130<sub>1</sub>-130<sub>4</sub>. Word lines WL7-WL0 112<sub>8</sub>-112<sub>1</sub> select the individual memory cells (e.g., 164<sub>1</sub>-164<sub>4</sub>) in the series strings to be written to, verified or read from and operate the remaining memory cells in each series string in a pass through mode. Each series string of memory cells is coupled to a source line 128 by a source select gate 106 and to an individual bit line BL0 130<sub>1</sub> by a drain select gate 104, for example. The source select gates, such as 106, are controlled by a source select gate control line SG(S) 110 coupled to their control gates. The drain select gates, such as 104, are controlled by a drain select gate control line SG(D) 108.

Memory cells 102 can be what are known in the art as Single Level Memory Cells (SLC) or Multilevel Memory Cells (MLC). SLC and MLC memory cells are assigned a data state (e.g., as represented by one or more bits) to a specific range of threshold voltages (V<sub>t</sub>) stored on the memory cell. Single level memory cells (SLC) permit the storage of a single binary digit (e.g., bit) of data on each memory cell. Meanwhile, MLC technology permits the storage of two or more binary digits per cell (e.g., 2, 4, 8, 16 bits), depending on the quantity of V<sub>t</sub> ranges assigned to the cell and the stability of the assigned V<sub>t</sub> ranges during the lifetime operation of the memory cell. The number of V<sub>t</sub> ranges (e.g., levels), used to represent a bit pattern comprised of N-bits is 2<sup>N</sup>, where N is an integer. For example, one bit may be represented by two levels, two bits by four levels, three bits by eight levels, etc. Some memory cells can store fractional numbers of bits, such as 1.5 bits per cell (e.g., MLC(three level)). A common naming convention is to refer to SLC memory as MLC(two level) memory as SLC memory utilizes two V<sub>t</sub> ranges in order to store one bit of data as represented by a 0 or a 1, for example. MLC memory configured to store two bits of data can be represented by MLC(four level), three bits of data by MLC(eight level), etc.

FIG. 2 illustrates an example of V<sub>t</sub> ranges 200 for a MLC (four-level) (e.g., 2-bit) memory cell. For example, a cell may be assigned a V<sub>t</sub> that falls within one of four different V<sub>t</sub> ranges 202-208 of 200 mV, each being used to represent a data state corresponding to a bit pattern comprised of two bits. As one example, if the voltage stored on the cell is within the first of the four V<sub>t</sub> ranges 202, the cell in this case is storing a logical '11' state and is typically considered the erased state of the cell. If the voltage is within the second of the four V<sub>t</sub> ranges 204, the cell in this case is storing a logical '10' state. A voltage in the third V<sub>t</sub> range 206 of the four V<sub>t</sub> ranges would indicate that the cell in this case is storing a logical '00' state. Finally, a V<sub>t</sub> residing in the fourth V<sub>t</sub> range 208 indicates that a logical '01' state is stored in the cell.

Referring again to FIG. 1, during a typical read operation of the memory array 100, NAND strings of memory cells coupled to even numbered bit lines (e.g., 130<sub>2</sub>, 130<sub>4</sub>) are read, followed by a read operation of the NAND strings coupled to odd numbered bit lines (e.g., 130<sub>1</sub>, 130<sub>3</sub>). During a read operation, bit lines to be read (e.g., not grounded to GND 146)

are precharged to a particular bias level, such as 0.5V, for example. A read operation may be performed of memory cells **164<sub>1</sub>-164<sub>4</sub>** of the row (e.g., word line) **WL4 112<sub>5</sub>**, for example. As the read operation is performed, the bit line being read can be discharged into the SRC line **128**. As a result, the SRC line **128** may experience what is referred to as source line bounce wherein the bias level of the source line rises in response to the bit lines being discharged into the SRC line **128**. This source line bounce can thereby introduce errors during a read operation of the memory.

For the reasons stated above, and for other reasons which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art to reduce the effects of source line bounce while sensing memory cells in a memory device.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a typical arrangement of multiple series strings of memory cells of a memory array organized in a NAND architecture.

FIG. 2 shows a graphical representation of threshold voltage ranges in a memory cell.

FIG. 3 shows a typical arrangement of two series strings of memory cells of a memory array organized in a NAND architecture.

FIG. 4 shows a typical arrangement of two series strings of memory cells of an array organized in a NAND architecture.

FIG. 5 shows an array of memory cells according to an embodiment of the present disclosure.

FIG. 6 shows an initial biasing condition of an array of memory cells undergoing a read operation according to an embodiment of the present disclosure.

FIG. 7 shows a biasing condition of an array of memory cells undergoing a read operation according to an embodiment of the present disclosure.

FIG. 8 shows an array of memory cells according to an embodiment of the present disclosure.

FIG. 9 shows a block diagram of a memory system that incorporates various embodiments of the present disclosure.

#### DETAILED DESCRIPTION

In the following detailed description of the present embodiments, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments in which the embodiments may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that process, electrical or mechanical changes may be made without departing from the scope of the present disclosure. The following detailed description is, therefore, not to be taken in a limiting sense.

FIG. 3 shows a typical array of memory cells **300** arranged in a NAND configuration similar to that shown in FIG. 1. FIG. 3 illustrates a single typical odd numbered and even numbered string of memory cells thereby simplifying and improving readability of the Figure. FIG. 3 also illustrates an example of initial biasing conditions for performing a read operation of the memory array **300**.

During a typical sensing operation (e.g., a read or verify operation) of the array **300**, either the even numbered bit lines, such as **320<sub>1</sub>**, or the odd numbered bit lines, such as **320<sub>2</sub>** are selected as part of the sense operation. Although reference to a read operation is made with respect to FIG. 3, the discussion would apply similarly to a verify operation

performed on the memory array **300** as well as a verify operation is also a method of reading a memory cell. In order to perform a read operation on memory cell **304<sub>1</sub>** for example, select gate **328** is disabled by biasing signal SGBL(EVEN) at **0V 330**. The adjacent odd numbered bit line **320<sub>2</sub>** is coupled to the GND **336** signal by driving the SGBL(ODD) signal **334** such that the select gate **332** is activated, such as to **4V**, for example. This effectively couples the odd numbered bit lines adjacent to the even numbered bit lines (e.g., selected bit lines) to GND **336**. The GND line **336** typically has a low voltage present, such as **0V**, for example. Thus, because the odd numbered bit lines are driven to the bias level of GND **336**, the odd numbered bit lines **320<sub>2</sub>** act as shielding while even numbered bit lines **320<sub>1</sub>** are being read. In a subsequent read operation, the roles of the odd numbered and even numbered bit lines are reversed. For example, the even numbered bit lines **320<sub>1</sub>** are coupled to the GND signal **336** to act as shields for odd numbered bit lines when odd numbered bit lines **320<sub>2</sub>** are selected for a read operation.

In a read operation of even numbered bit lines **320<sub>1</sub>**, the even bit lines are biased (e.g., pre-charged) to a particular bias level. For example, bit line **320<sub>1</sub>** might initially be biased to a level of **0.5 V**, for example. Odd numbered bit lines **320<sub>2</sub>** are biased at the bias level of the GND signal **336** through the enabled **332** select gate. For example, **0V** as shown on GND **336** shown in FIG. 3. This is further indicated by a **0V** bias shown on odd bit line **320<sub>2</sub>**.

The circle surrounding memory cell **304<sub>1</sub>** indicates that it is a memory cell targeted for a read operation. Although not shown in the Figure, other memory cells of the array **300** coupled to row **312<sub>2</sub>** (e.g., **WL4**) and coupled to additional even bit lines (not shown) would also be targeted to be read along with memory cell **304<sub>1</sub>**. During the read operation, rows not comprising memory cells to be read (e.g., **312<sub>1</sub>**, **312<sub>3</sub>**) are biased at a bias level (e.g., **Vpass**) that renders the unselected memory cells (e.g., **348**) in a pass through mode. Drain select gates **302** (coupled to data lines **320**) and source select gates **306** (coupled to source **318**) are also enabled to allow current to flow through each selected NAND string. Thus, the flow of current in a selected NAND string during a read operation is dependent on the data state (e.g., **Vt** level) of the target memory cell, such as **304<sub>1</sub>** of FIG. 3. That is, during the read operation, the target memory cell **304<sub>1</sub>** will be selectively activated in response to its data state.

FIG. 4 illustrates the same array of memory cells as **300**. However, FIG. 4 illustrates different biasing conditions in the array as a result of performing a read operation on the array **400**.

One source of error during a read operation can occur as a result of a transient condition often referred to as source line bounce. Source line bounce occurs as the pre-charged bit line is discharged into the source line. Because the source line **418** has a finite resistance, current flowing into it causes the potential of the source line to increase, as indicated by the bias level of **0.1V** as shown on SRC **418** of FIG. 4. This in effect reduces voltage across the NAND string being read (e.g., across the drain side of the NAND string **444** to the source side of the NAND string **446**), sometimes referred to in the art as string VDS. String VDS typically refers to the voltage present across the NAND string of memory cells including the voltage across the drain select gate **402** and the source select gate **406**. This has the overall effect of changing the read potential on the pre-charged bit line discussed above which in one example is **0.5V**. The **0.1V** of source line bounce as shown in FIG. 4 results in an effective read voltage across the string (e.g., string VDS) of the even bit line **420<sub>1</sub>** to no longer be the original pre-charge bias of **0.5V** but instead is now **0.4V** (e.g.,

5

0.5V-0.1V), for example. This can introduce read errors during a read operation of the memory device.

In addition, the source line bounce can vary depending on the data state of each memory cell being read. For example, one NAND string of memory cells being read might experience more source line bounce than another NAND string of memory cells being read during the same read operation. This occurs as each NAND string can have different magnitudes of current flow through them which is at least partially dependent on the data state of each memory cell of a selected row. This results in a different level (e.g., magnitude) of source line bounce present at the source side of each source select gate 406 of each NAND string being read. Source line bounce can also occur locally with respect to the source side connection of a given NAND string to the SRC line. For example, one memory cell of a selected row of memory cells might be programmed whereas another memory cell of the same row may not be programmed (e.g., erased state). A programmed memory cell is going to conduct a different amount of current through its NAND string than the un-programmed (e.g., erased) memory cell is going to conduct through its NAND string. This results in the programmed memory cell being read at a different read voltage than the un-programmed memory cell will be read at due to the source line bounce occurring near the NAND string of the un-programmed memory cell. Although source line bounce was discussed above with respect to a read operation of even numbered bit lines 420<sub>1</sub>, the same effects apply in the case of reading odd numbered bit lines 420<sub>2</sub> undergoing a read (or verify) operation.

FIG. 5 illustrates an array 500 of memory cells 502 according to an embodiment of the present disclosure which should reduce the effect of source line bounce as discussed with respect to FIGS. 3 and 4. FIG. 5 illustrates an array of memory cells 500 arranged in a number of NAND configured strings 568 each coupled to a respective bit line BL0-BL3 530<sub>1</sub>-530<sub>4</sub>. Each string of memory cells 568 comprises a drain select gate 504, a string of memory cells 502 each having a control gate coupled to a word line 512<sub>8</sub>-512<sub>1</sub> and a source select gate 506. Each bit line BL0-BL3 530<sub>1</sub>-530<sub>4</sub> is coupled to a sense device 538<sub>1</sub>-538<sub>4</sub> as are known to those skilled in the art. FIG. 5 also shows additional select gates 556<sub>1</sub>-556<sub>2</sub>, 560<sub>1</sub>-560<sub>2</sub> which allow for reading even numbered bit lines during a first read operation and reading odd numbered bit lines during a second read operation, for example. Select gates 556<sub>1</sub>-556<sub>2</sub> are controlled by the SGBL(ODD) signal 552. Select gates 560<sub>1</sub>-560<sub>2</sub> are controlled by the SGBL(EVEN) signal 554. Although shown in FIG. 5 as single select gates, each select gate 556<sub>1</sub>-556<sub>2</sub>, 560<sub>1</sub>-560<sub>2</sub> can be comprised of multiple gates such as two or more gates coupled in series and/or parallel configurations according to various embodiments of the present disclosure. For example, select gate 556<sub>1</sub> might be comprised of two or more gates coupled in series.

It should be noted that according to one or more embodiments, the odd/even bit line select gates 556<sub>1</sub>-556<sub>2</sub>, 560<sub>1</sub>-560<sub>2</sub> couple the bit lines BL0-BL3 530<sub>1</sub>-530<sub>4</sub> not to the GND signal as is shown in FIGS. 1, 3 and 4, but instead couple the bit lines to the SRC line 528. It should be noted further that the SRC line 528 is located inside the memory cell array of the device and is not directly coupled to nor is it equivalent to the GND signal and/or a V<sub>ss</sub> input pin of the integrated circuit device (e.g., chip), for example. The SRC line 528 might be biased to a particular bias level under a number of array biasing scenarios independent of the GND signal. In addition, select gates 556/560 can be smaller in size than the larger, high voltage select gates 156/160 discussed above with respect to FIG. 1. This can provide savings in the total area of

6

the die of approximately 1%, for example. Thus, according to various embodiments of the present disclosure, bit lines acting as shields during a read operation of adjacent bit lines are biased to the SRC line of the adjacent bit line being read. Source line bounce occurring as a result of the read operation of a selected bit line is thereby coupled onto the adjacent bitline acting as a shield. For example, odd bit lines 530<sub>2</sub>, 530<sub>4</sub> act as shields during a read operation of their adjacent even numbered bit lines 530<sub>1</sub>, 530<sub>3</sub>. During the read operation, source line bounce can occur as discussed above. However, according to one or more embodiments, the source line bounce occurring as a result of the read operation is coupled onto the adjacent bit line acting as the shield. For example, during a read operation of even bit lines such as 530<sub>3</sub>, bit lines 530<sub>2</sub> and 530<sub>4</sub> are coupled to the SRC line 528 through their respective select gates 556<sub>1</sub>, 556<sub>2</sub> which are controlled by the SGBL(ODD) signal 552. Thus, bit line BL1 530<sub>2</sub> and bit line BL3 530<sub>4</sub> act as shields with respect to bit line BL2 530<sub>3</sub> during a read operation of even bit lines, for example. During a read operation of odd bit lines, even bit lines BL0 530<sub>1</sub> and BL2 530<sub>3</sub> serve as shields for bit line BL1 530<sub>2</sub>, for example.

Although FIG. 5 illustrates bit lines BL0-BL3 530<sub>1</sub>-530<sub>4</sub> and their associated select gates 556<sub>1</sub>-556<sub>2</sub>, 560<sub>1</sub>-560<sub>2</sub> coupled to one of two select signals SGBL(ODD) 552 and SGBL(EVEN) 554, various embodiments of the present disclosure are not so limited. For example, the grouping of bit lines is not limited to odd and even numbered bit lines. Although not shown in FIG. 5, additional embodiments might have bit lines grouped into three or more separate groups wherein each group of bit lines can be selectively coupled to the SRC line 528, for example. Similar to signal SGBL(ODD) 552 and signal SGBL(EVEN) 554 along with their respective select gates 556 and 560, one or more embodiments of the present disclosure might instead utilize a SGBL(ONE), SGBL(TWO) and SGBL(THREE) select signal along with associated select gates to selectively couple three independent groupings of bit lines to the SRC line 528, for example. It should be noted that many more bit lines, word lines and memory cells than are shown in FIG. 5 can be present in a memory device according to various embodiments of the present disclosure.

FIG. 6 illustrates an initial biasing condition for a read or a verify operation of an array of memory cells 600 according to one or more embodiments of the present disclosure. FIG. 6 illustrates a single even bit line 620<sub>1</sub> and a single odd bit line 620<sub>2</sub>. However, many more even and odd (e.g., alternating) bit lines are possible according to various embodiments of the present disclosure. FIG. 6 shows the initial biasing conditions to perform a read operation of even bit lines 620<sub>1</sub> of an array 600, for example. The even bit line 620<sub>1</sub> is pre-charged to 0.5V and the bias of the SRC line 618 is 0V, for example. Thus, the string VDS of the even string 620<sub>1</sub> shown in FIG. 6 is 0.5V. The SGBL(ODD) signal 634 is shown biased at 4V in order to enable (e.g., turn on) select gate 632 thereby selectively coupling the BL<sub>ODD</sub> 620<sub>2</sub> bit line to the common SRC line 618. Following the establishment of these initial biasing conditions as shown in FIG. 6, the word line selected for reading (e.g., 612<sub>2</sub>) is biased to begin performing the read operation of the selected memory cell 604<sub>1</sub>, for example.

FIG. 7 illustrates the same memory array as that shown in FIG. 6. However, FIG. 7 shows a possible biasing condition of the array as the selected memory cell 704<sub>1</sub> is read. Although not shown in the Figure, many more memory cells of even bit lines and word line WL4 712<sub>2</sub> may be read concurrently with memory cell 704<sub>1</sub>. During the read operation of memory cell 704<sub>1</sub>, select gate 728 is disabled and select gate 732 is enabled. As part of the read operation, bit line 720<sub>1</sub> is pre-

charged to a particular voltage such as 0.5V (e.g., as shown in FIG. 6), for example. During the read operation of memory cell **704**<sub>1</sub>, source line bounce of 0.1V is indicated in the Figure on the SRC line **718**. As BL<sub>EVEN</sub> **720**<sub>1</sub> and BL<sub>ODD</sub> **720**<sub>2</sub> share a common SRC line **718** and select gate **732** is enabled, the 0.1V of source line bounce is coupled onto bit line **720**<sub>2</sub> as indicated in the Figure. A capacitive coupling effect **752** occurs between the even bit line BL<sub>EVEN</sub> **720**<sub>1</sub> and the odd bit line BL<sub>ODD</sub> **720**<sub>2</sub> serving as the shield for BL<sub>EVEN</sub> **720**<sub>1</sub>. Thus, as indicated in FIG. 7, at least part of the source line bounce that was coupled onto the odd bit line is reflected onto the drain side of the string VDS of bit line **720**<sub>1</sub> (e.g., at and/or near node **750**). This capacitive coupling effect **752** may result in a string VDS of 0.485V as indicated on bit line **720**<sub>1</sub>, for example. Thus, according to one or more embodiments of the present disclosure, the effect of source line bounce has been reduced resulting in a string VDS read voltage (e.g., 0.485V) closer to the original pre-charge bias (e.g., 0.5V) thereby reducing read errors during the read operation. It should be noted that the various embodiments of the present disclosure are not limited to the biasing conditions illustrated in FIG. 7. Different source line bounce, pre-charge voltages and resulting effective read voltages (e.g., string VDS) are possible according to various embodiments of the present disclosure.

FIG. 8 illustrates another array of memory cells **800** according to various embodiments of the present disclosure. The array **800** comprises both select gates (e.g., drain, source) and non-volatile memory cells, such as flash memory cells, for example. The memory cells of array **800** are arranged in multiple blocks of memory having a NAND string configuration such as memory cells shown in string **804**, for example. String **804** is shown coupled to n word lines (e.g., WL<sub>0</sub>-WL<sub>n</sub>) **834**. Various embodiments may utilize NAND strings coupled to many word lines such as 8, 16 or 32 word lines per NAND string, for example. Each NAND string **804** of FIG. 8 and its associated word lines **834** and select lines **838**, **840**, are similar to those illustrated in FIG. 5. For example, string **804** can comprise a string such as the string of FIG. 5 comprising drain select gate **504** through source select gate **506**. Signals **834** can comprise signals **512**<sub>8</sub>-**512**<sub>1</sub>, for example. Each NAND string of FIG. 8 (e.g., **804**) is selectively coupled to a source line (e.g., **824**<sub>4</sub> at **814**) and a bit line (e.g., **816**<sub>3</sub> at **818**) as shown in the Figure, for example. Although not explicitly shown in the Figure, multiple source lines designated as SRC1-SRC5 **824**<sub>1</sub>-**824**<sub>5</sub> illustrated in FIG. 8 are each coupled together. As such, a source line bounce experienced on one of the source lines SRC1-SRC5 **824**<sub>1</sub>-**824**<sub>5</sub> is coupled to all of the source lines SRC1-SRC5 **824**<sub>1</sub>-**824**<sub>5</sub>. Sense devices, such as **538**<sub>1</sub>-**538**<sub>4</sub> shown coupled to each bit line **530**<sub>1</sub>-**530**<sub>4</sub> of FIG. 5 are not shown in FIG. 8 to improve the readability of the Figure.

Additional select gates, such as **802**, **810** can serve as select gates **560**<sub>2</sub>, **556**<sub>2</sub>, respectively, for example. For example, select gates **802** serve to couple **808** the even numbered bit line BL<sub>2</sub> **816**<sub>3</sub> to the SRC1 **824**<sub>1</sub> and SRC2 **824**<sub>2</sub> connections when odd numbered bit lines are being read. During a read operation on odd numbered bit lines, the select gates **810** are disabled while the select gates **802** are enabled (e.g., activated) to couple the even numbered bit lines to one or more source lines, such as SRC1 and SRC2, for example. During a read operation of even numbered bit lines (e.g., reading string **804**), select gates **802** are disabled (e.g., deactivated) to uncouple the even bit line **816**<sub>3</sub> from a source line connection. Select gates **802** are disabled due to the 0V bias condition shown associated with signals **842** that are coupled to select gates **802**. During a read operation of even numbered bit lines,

select gates **810** are enabled (e.g., activated) to couple **812** the odd numbered bit lines to one or more source lines, such as SRC3 **824**<sub>3</sub> and SRC4 **824**<sub>4</sub>, for example. Select gates **810** are enabled as shown in FIG. 8 by the 4V bias level associated with signals **846** which are coupled to gates **810**. This repeats across the array of even numbered and odd numbered (e.g., alternate) bit lines of the array **800**. It should be noted that various embodiments of the present disclosure are not limited to the biasing conditions as shown in FIG. 8. Although each string of select gates **802**, **810** comprise four individual gates, various embodiments of the present disclosure are not so limited. Each pair of gates, such as **850**, can be comprised of a single gate instead of two gates as shown in FIG. 8, for example. Further, there may be more or less of the strings of gates such as **806** and/or those gates shown coupled to signals **844**. For example, these strings of gates (e.g., **806**) might be included in a design to adjust for spacing issues in the circuit layout, for example.

Although references to read operations are described with respect to FIG. 8, various embodiments of the present disclosure are not limited to read operations performed but also apply to other memory device operations, such as performing verify operations, for example.

Various embodiments of the present disclosure are not limited to the arrangement and connections of select gates and memory cells as shown in FIG. 8. For example, the location in an array of the bit line coupling gates (e.g., those shown between SRC1 **824**<sub>1</sub> and SRC4 **824**<sub>4</sub>) might vary according to various embodiments of the present disclosure. These gates and control signals might be located at either end of an array and/or may be present in the middle of an array, for example. The various embodiments also include multiple sets of these gates and control signals. For example, according to one or more embodiments, a group of these gates (e.g., gates shown between SRC1 **824**<sub>1</sub> and SRC4 **824**<sub>4</sub>) may be located at one or both ends of the array with another group of gates located at some point in between, such as at a midpoint of the array, for example. Additionally, a memory device according to various embodiments of the present disclosure can have many more blocks of memory than those shown in FIG. 8. For example, each group of bit line coupling gates (e.g., gates shown between SRC1 **824**<sub>1</sub> and SRC4 **824**<sub>4</sub>) may be utilized for multiple blocks of memory such as **512** blocks of memory, for example. As discussed with respect to FIGS. 5, 6 and 7, embodiments of the present disclosure such as shown in FIG. 8, provide for alternating bit lines to serve as shields to their adjacent bit lines during read operations and further provide for capacitive coupling between a bit line acting as a shield and an adjacent bit line in order to reduce the effects of source line bounce.

FIG. 9 is a functional block diagram of an electronic system having at least one memory device according to one or more embodiments of the present disclosure. The memory device **900** illustrated in FIG. 9 is coupled to a host such as a processor **910**. The processor **910** may be a microprocessor or some other type of controlling circuitry. The memory device **900** and the processor **910** form part of an electronic system **920**. The memory device **900** has been simplified to focus on features of the memory device that are helpful in understanding various embodiments of the present disclosure.

The memory device **900** includes one or more arrays of memory cells **930** that can be arranged in banks of rows and columns. Memory array **930** may comprise SLC and/or MLC memory, for example. According to one or more embodiments, the memory cells of memory array **930** are flash memory cells. The memory array **930** can consist of multiple banks and blocks of memory cells residing on a single or

multiple die as part of the memory device **900**. The memory cells of the memory array **930** may also be adaptable to store varying densities (e.g., MLC(four level) and MLC(eight level)) of data in each cell, for example.

An address buffer circuit **940** is provided to latch address signals provided on address input connections **A0-Ax 942**. Address signals are received and decoded by a row decoder **944** and a column decoder **946** to access the memory array **930**. It will be appreciated by those skilled in the art, with the benefit of the present description, that the number of address input connections **942** depends on the density and architecture of the memory array **930**. That is, the number of addresses increases with both increased memory cell counts and increased bank and block counts.

The memory device **900** reads data in the memory array **930** by sensing voltage or current changes in the memory array columns using sense/data cache circuitry **950**. The sense/data cache circuitry **950**, in at least one embodiment, is coupled to read and latch a row of data from the memory array **930**. Sense devices **538** such as those discussed with respect to FIG. **5** can also comprise the sense/data cache circuitry **950**, for example. Data input and output buffer circuitry **960** is included for bi-directional data communication over a plurality of data connections **962** with the processor **910**. Write circuitry **955** is provided to write data to the memory array **930**.

Control circuitry **970** is configured at least in part to implement various embodiments of the present disclosure, such as selectively enabling (e.g., driving) the bit line select gates **802, 810** to the source end of strings of memory cells **804/836**, for example. In at least one embodiment, the control circuitry **970** may utilize a state machine. Control signals and commands can be sent by the processor **910** to the memory device **900** over the command bus **972**. The command bus **972** may be a discrete signal or may be comprised of multiple signals, for example. These command signals **972** are used to control the operations on the memory array **930**, including data read, data write (program), and erase operations. The command bus **972**, address bus **942** and data bus **962** may all be combined or may be combined in part to form a number of standard interfaces **978**. For example, the interface **978** between the memory device **900** and the processor **910** may be a Universal Serial Bus (USB) interface. The interface **978** may also be a standard interface used with many hard disk drives (e.g., SATA, PATA) as are known to those skilled in the art.

The electronic system illustrated in FIG. **9** has been simplified to facilitate a basic understanding of the features of the memory and is for purposes of illustration only. A more detailed understanding of internal circuitry and functions of non-volatile memories are known to those skilled in the art.

## CONCLUSION

Various embodiments of the present disclosure provide methods for biasing signal levels in a memory device such as coupling unselected bit lines to a source line common to a source line selectively coupled to adjacent strings of memory cells, for example. Also disclosed are apparatus configured to perform the methods of various embodiments of the present disclosure. According to various embodiments of the present disclosure, a reduction in the effects of source line bounce during a read operation in a memory device can be realized.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement that is calculated to achieve the same purpose may be substituted for the specific embodiments shown. Many adaptations of the disclosure will be apparent to those of ordinary skill in the art. Accordingly, this application is intended to cover any adaptations or variations of the disclosure.

What is claimed is:

**1.** A method of operating an array of memory cells, the method comprising:

coupling a first end of a first string of memory cells to a first data line and coupling a second end of the first string of memory cells to a source;

coupling a first end of a second string of memory cells to a second data line and coupling a second end of the second string of memory cells to the source;

biasing the second data line to a potential of the source by coupling the second data line to the source regardless of states of the memory cells of the second string of memory cells; and

performing a sense operation on a selected memory cell of the first string of memory cells while the second data line is biased to the potential of the source and while the second data line is coupled to the source regardless of the states of the memory cells of the second string of memory cells; and

charging the first data line to a particular potential prior to performing the sense operation on the selected memory cell of the first string of memory cells;

wherein the first data line is decoupled from the source while charging the first data line to the particular potential.

**2.** The method of claim **1**, wherein the first data line is different than the second data line.

**3.** The method of claim **1**, wherein the potential of the source is different than the particular potential.

**4.** A method of operating an array of memory cells, the method comprising:

coupling a first end of a first string of memory cells to a first data line and coupling a second end of the first string of memory cells to a source;

coupling a first end of a second string of memory cells to a second data line and coupling a second end of the second string of memory cells to the source;

biasing the second data line to a potential of the source by coupling the second data line to the source regardless of states of the memory cells of the second string of memory cells; and

performing a sense operation on a selected memory cell of the first string of memory cells while the second data line is biased to the potential of the source and while the second data line is coupled to the source regardless of the states of the memory cells of the second string of memory cells;

wherein the first data line is decoupled from the source while biasing the second data line to the potential of the source.

**5.** The method of claim **4**, wherein the selected memory cell of the first string of memory cells and a particular memory cell of the second string of memory cells are commonly coupled to an access line, wherein coupling the second data line to the source regardless of the states of the memory cells of the second string of memory cells comprises coupling the second data line to the source regardless of whether the particular memory cell of the second string of memory cells is activated during the sense operation on the selected memory cell of the first string of memory cells.

**6.** A memory device, comprising:

a first data line;

a second data line;

a first string of memory cells selectively coupled between the first data line and a source;

a second string of memory cells selectively coupled between the second data line and the source; and

## 11

control circuitry, wherein the control circuitry is configured to bias the second data line to a potential of the source by causing the second data line to be coupled to the source regardless of states of the memory cells of the second string of memory cells and to perform a sense operation on a target memory cell of the first string of memory cells while the second data line is biased to the potential of the source and while the second data line is coupled to the source regardless of the states of the memory cells of the second string of memory cells;

wherein the control circuitry is configured to cause the first data line to be decoupled from the source while the second data line is biased to the potential of the source.

7. The memory device of claim 6, further comprising first sense circuitry coupled to the first data line and second sense circuitry coupled to the second data line.

8. The memory device of claim 6, wherein the first data line is adjacent to the second data line.

9. The memory device of claim 6, wherein the target memory cell of the first string of memory cells and a particular memory cell of the second string of memory cells are commonly coupled to an access line, wherein causing the second data line to be coupled to the source regardless of the states of the memory cells of the second string of memory cells comprises coupling the second data line to the source regardless of whether the particular memory cell of the second string of memory cells conducts during the sense operation on the target memory cell of the first string of memory cells.

10. A memory device, comprising:

a first data line;

a second data line;

a first string of memory cells selectively coupled between the first data line and a source;

a second string of memory cells selectively coupled between the second data line and the source;

control circuitry, wherein the control circuitry is configured to bias the second data line to a potential of the source by causing the second data line to be coupled to the source regardless of states of the memory cells of the second string of memory cells and to perform a sense operation on a target memory cell of the first string of memory cells while the second data line is biased to the potential of the source and while the second data line is coupled to the source regardless of the states of the memory cells of the second string of memory cells; and first sense circuitry coupled to the first data line and second sense circuitry coupled to the second data line;

wherein the first sense circuitry is configured to charge the first data line to a particular potential prior to the sense operation performed on the target memory cell of the first string of memory cells while the second data line is biased to the potential of the source line; and

wherein the control circuitry is configured to cause the first data line to be decoupled from the source while the first data line is charged to the particular potential.

## 12

11. The memory device of claim 10, wherein the potential of the source is different than the particular potential.

12. A method of operating an array of memory cells, the method comprising:

coupling a first end of a first string of memory cells to a first data line and coupling a second end of the first string of memory cells to a source;

coupling a first end of a second string of memory cells to a second data line and coupling a second end of the second string of memory cells to the source;

biasing to a bias level an access line to which a selected memory cell of the first string of memory cells and a particular memory cell of the second string of memory cells are commonly coupled; and

performing a sense operation on the selected memory cell of the first string of memory cells while biasing the access line to the bias level, and while the second data line is coupled to the source regardless of whether biasing the access line to the bias level activates the particular memory cell of the second string of memory cells, and while the second data line is biased to a potential of the source;

wherein the first data line is decoupled from the source while the second data line is biased to the potential of the source.

13. A method of operating an array of memory cells, the method comprising:

coupling a first end of a first string of memory cells to a first data line and coupling a second end of the first string of memory cells to a source;

coupling a first end of a second string of memory cells to a second data line and coupling a second end of the second string of memory cells to the source;

biasing to a bias level an access line to which a selected memory cell of the first string of memory cells and a particular memory cell of the second string of memory cells are commonly coupled;

performing a sense operation on the selected memory cell of the first string of memory cells while biasing the access line to the bias level, and while the second data line is coupled to the source regardless of whether biasing the access line to the bias level activates the particular memory cell of the second string of memory cells, and while the second data line is biased to a potential of the source; and

charging the first data line to a particular potential prior to biasing the access line to the bias level;

wherein the first data line is decoupled from the source while charging the first data line to the particular potential.

14. The method of claim 13, wherein the potential of the source is different than the particular potential.

\* \* \* \* \*



UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 9,406,389 B2  
APPLICATION NO. : 14/535567  
DATED : August 2, 2016  
INVENTOR(S) : Uday Chandrasekhar

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page, at Item (54) and in the Specification, Column 1, please delete  
“ELECTRONICALLY COUPLING A DATA LINE TO A SOURCE FOR BIASING REGARDLESS  
OF STATES OF MEMORY CELLS COUPLED TO THE DATA LINE” and insert in place thereof --  
ELECTRICALLY COUPLING A DATA LINE TO A SOURCE FOR BIASING REGARDLESS OF  
STATES OF MEMORY CELLS COUPLED TO THE DATA LINE --.

Signed and Sealed this  
Eleventh Day of October, 2016



Michelle K. Lee  
*Director of the United States Patent and Trademark Office*